Physics Aspects of Software

I. Hinchliffe, LBNL

Connections between physics and software in development phase

- Requirements
- Testing and Evaluation
- Usage

On project activities – Physics Generators

- Monte Carlo Packages - maintenance and support.
- ATLAS (Athena) integration

Current U.S. Physics Activities (off computing project)

- Current Responsibles/activities
- Future activities.

Connections in development phase

The software and hardware are not ends in themselves, they are a service that enables physics to get done

Physicist involvement is essential during requirements and design phase

Ongoing physics simulation provides testing and requirements

simulation code always needed to understand changes

recent examples

- Pixels becoming fully insert-able
- Physics impact of possible upgrades

Large scale tests are provided by Mock Data Challenges

Expected to begin end 2001

Essential for testing complete system

Provides experience for Tier11/Tier0/Users: Access and and usage patterns

Created Mon Oct 23 11:24:09 GMT-0700 (PDT) 2000

WBS Num	Description	ATLAS WBS
2.1	**Physics**	**2**

ID: /physics Funded: Both Mgr: F.Gianotti U.S.Mgr: I.Hinchliffe U.S.Contact: I.Hinchliff
1999/12/13: Generators: Interface Pythia to HepMC++ Done!
2000/5/22: ATLAS Physics Workshop Done!
2000/7/3: All major generators interfaced to HepMC++
2000/8/15: Major Generators Interfaced to Framework
2000/9/29: PYTHIA and ISAJET interfaced to framework Done! Time variance -1mo
2000/9/29: HERWIG interfaced to framework
2000/12/1: Start generating full simu samples with new framework
2001/6/29: Library of generators available
2001/8/1: Library of MC generators available
2001/9/15: ATLAS physics workshop
Hinchliffe (LBNL) 0/0.6 1/0.5 2/0.3 3/0.3 4/0.3 5/0.3

2.1.1 Support of Monte-carlo Generators

ID: /physics/mcgen Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
Maintenence of interfaces between generators and atlas code
Maintenance of third party software in atlas repository
Hinchliffe (LBNL)
LbnlPhysicsHire (LBNL) 2/1.0 3/1.0 4/1.0 5/1.0

2.1.1.1 Generator Independent Framework Interface

ID: /physics/mcgen/intfc Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
General interface code from which all specific generator interface implementations inherit.
One FTE month to get started and 0.05 ongoing.
Startup is done (M.Shapiro) and maintenance is ongoing (I.Hinchliffe)

2.1.1.2 Isajet

ID: /physics/mcgen/isajet Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
(currently US responsibility)

2.1.1.2.1 Maintenance of external package

ID: /physics/mcgen/isajet/maint Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up
Shank (Boston) 0/0.1 1/0.05 2/0.05 3/0.05 4/0.05 5/0.05

2.1.1.2.2 Interface to Framework

ID: /physics/mcgen/isajet/intfc Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
This is 0.05 FTE (ongoing) + 1 FTE month to start up
Hinchliffe (LBNL) 0/0.1 1/0.05
LbnlPhysicsHire (LBNL) 2/0.05 3/0.05 4/0.05 5/0.05

2.1.1.3 Pythia 6

ID: /physics/mcgen/pythia6 Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
(Currently UK/US responsibility)

2.1.1.3.1 **Maintenance of external package**

ID: /physics/mcgen/pythia6/maint Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up
Glasgow (Stan Thompson)

2.1.1.3.2 **Interface to Framework**

ID: /physics/mcgen/pythia6/intfc Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
This is 0.05 FTE (ongoing) + 1 FTE month to start up
Hinchliffe (LBNL) 0/0.1 1/0.05
LbnlPhysicsHire (LBNL) 2/0.05 3/0.05 4/0.05 5/0.05

2.1.1.4 **Herwig**

ID: /physics/mcgen/herwig Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
(currently US responsibility)

2.1.1.4.1 **Maintenance of external package**

ID: /physics/mcgen/herwig/maint Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up
Hinchliffe (LBNL) 0/0.1 1/0.05
LbnlPhysicsHire (LBNL) 2/0.05 3/0.05 4/0.05 5/0.05

2.1.1.4.2 **Interface to Framework**

ID: /physics/mcgen/herwig/intfc Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
This is 0.05 FTE (ongoing) + 1 FTE month to start up
Hinchliffe (LBNL) 0/0.1 1/0.05
LbnlPhysicsHire (LBNL) 2/0.05 3/0.05 4/0.05 5/0.05

2.1.1.5 **Stdhep**

ID: /physics/mcgen/stdhep Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
(currently US responsibility)

2.1.1.5.1 **Maintenance of external package**

ID: /physics/mcgen/stdhep/maint Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up

2.1.1.5.2 **Interface to Framework**

ID: /physics/mcgen/stdhep/intfc Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
This is 0.05 FTE (ongoing) + 1 FTE month to start up

2.1.1.6 **Pythia 7**

ID: /physics/mcgen/pythia7 Funded: Both U.S.Contact: I.Hinchliffe US: no
(Currently CERN responsibility)

2.1.1.6.1 **Maintenance of external package**

ID: /physics/mcgen/pythia7/maint Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up
Maya Stavrianikou, CERN

2.1.1.6.2 **Interface to Framework**

ID: /physics/mcgen/pythia7/intfc Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 1 FTE month to start up
No current activity

2.1.1.7 **Herwig ++**

ID: /physics/mcgen/herwigpp Funded: Both U.S.Contact: I.Hinchliffe US: unknown
(Future)

2.1.1.7.1 **Maintenance of external package**

ID: /physics/mcgen/herwigpp/maint Funded: Both U.S.Contact: I.Hinchliffe US: unkr
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up

2.1.1.7.2 **Interface to Framework**

ID: /physics/mcgen/herwigpp/intfc Funded: Both U.S.Contact: I.Hinchliffe US: unkr
This is 0.05 FTE (ongoing) + 1 FTE month to start up

2.1.1.8 **B-decay packages (EvtGen)**

ID: /physics/mcgen/bdecay Funded: Both U.S.Contact: I.Hinchliffe US: no

2.1.1.8.1 **Maintenance of external package**

ID: /physics/mcgen/bdecay/maint Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up
Maria Smizanska (U of Lancaster)

2.1.1.8.2 **Interface to Framework**

ID: /physics/mcgen/bdecay/intfc Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 1 FTE month to start up

2.1.1.9 **Vecbos**

ID: /physics/mcgen/vecbos Funded: Both U.S.Contact: I.Hinchliffe US: no

2.1.1.9.1 **Maintenance of external package**

ID: /physics/mcgen/vecbos/maint Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up
Davide Costanzo (Pisa)

2.1.1.9.2 **Interface to Framework**

ID: /physics/mcgen/vecbos/intfc Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 1 FTE month to start up
TBD

2.1.1.10 **Tauola**

ID: /physics/mcgen/tauola Funded: Both U.S.Contact: I.Hinchliffe **US: yes**

2.1.1.10.1 **Maintenance of external package**

ID: /physics/mcgen/tauola/maint Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up
Elzbieta Richter Was (Cracow)

2.1.1.10.2 **Interface to Framework**

ID: /physics/mcgen/tauola/intfc Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
This is 0.05 FTE (ongoing) + 1 FTE month to start up
IH currently, acitivity has not yet started
LbnlPhysicsHire (LBNL) 2/0.05 3/0.05 4/0.05 5/0.05

2.1.1.11 **Photos**

ID: /physics/mcgen/photos Funded: Both U.S.Contact: I.Hinchliffe US: no

ID: /physics/mcgen/photos Funded: Both U.S.Contact: I.Hinchliffe US: no

2.1.1.11.1 Maintenance of external package

ID: /physics/mcgen/photos/maint Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up
No current responsible

2.1.1.11.2 Interface to Framework

ID: /physics/mcgen/photos/intfc Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 1 FTE month to start up
No current responsible

2.1.1.12 Next to Leading order Parton Generators

ID: /physics/mcgen/nlo Funded: Both U.S.Contact: I.Hinchliffe US: no
Note this may need to be subdivided

2.1.1.12.1 Maintenance of external package

ID: /physics/mcgen/nlo/maint Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 0.5 FTE month to start up
Stephane Frixione (INFN)

2.1.1.12.2 Interface to Framework

ID: /physics/mcgen/nlo/intfc Funded: Both U.S.Contact: I.Hinchliffe US: no
This is 0.05 FTE (ongoing) + 1 FTE month to start up
No current responsible

2.1.2 Coordination of Mock data challenges

ID: /physics/mdc Funded: Both U.S.Contact: I.Hinchliffe **US: yes**
Hinchliffe (LBNL)

2.1.2.1 Selection of physics data sets

ID: /physics/mdc/physics Funded: Both U.S.Contact: I.Hinchliffe **US: yes**

Items: 38

On project physics activities
Support of Physics Generators
Effort directed by Atlas Monte-Carlo group led by Hinchliffe

Need ATLAS copies so that version control can be maintained.

Atlas Responsibles maintain links with authors

Activity started over last 12 months (WBS 2.1.1.X.1)

- Pythia S. Thompson (UK)
- Isajet J. Shank (US)
- Pythia7 M. Stavrianakou (CERN)
- Herwig I Hinchliffe (US)
- StdHep I. Hinchliffe (US)
- Tauola E. Richter Was (Poland)
- Vecbos D. Costanzo (Italy)
- others not yet assigned (see WBS for list)

Athena Interfaces (WBS 2.1.1.X.2)

Currently exclusive US responsibility (Hinchliffe/Shapiro)

Requirements

- Output from all generators in common format. This is HepMC which is now adopted by CLHEP
- Use one generator for High P_t process and another for MinBias
- Read events from pre-existing files OR generate on the fly
- Use same interface for full or fast simulation
- Add selection modules (filters)
- Select Generator and set parameters at run-time

Note HepMC used as interface between generator and simulation and also between generators and decay packages. This is an ATLAS product which will be taken over by CLHEP and supported for Geant-4.

Methodology and Status

- EventService for generating event header and common (Event/EventManagement classes) (Done)
- Atlas Specific Tunings should reside here so that they are loaded automatically
- Single Particle Gun Done
- Isajet Done
- Pythia Done
- Herwig next release
- Provided Interface to pass parameters at run-time
- Now gets parameters via JobOptions service (Scripting interface will improve this)

- Used by new fast simulation, part of December 00 Milestone Other Generators/decay packages will be added in 2001
  – Manpower limited
  Note: Support person added in FY02 to assume responsibilities for development/maintenance of these interfaces (2.1.1.X.2)
  A software agreement will be negotiated to cover this activity

Particle Properties Service (WBS 2.2.1.2.14

- US responsibility (Hinchliffe/Shapiro)
- Current service is a stopgap
- Will migrate service to Gaudi
- Working with CLHEP (alpha release expected Dec 2000)
- Evaluate and Integrate CLHEP tool in 2001

Current non project physics U.S Activities

- Physics is led by Physics Coordinator (F. Gianotti, CERN) and the Physics Coordination team (20 members)
- Several U.S.ATLAS members have leadership of some physics groups

  J. Parsons – Top and other Heavy quarks and Leptons

  F. Paige – Supersymmetry

  I. Hinchliffe – Monte-Carlos

  I. Hinchliffe – Deputy Physics coordinator

  M. Shupe – Backgrounds Group, responsible for understanding backgrounds particularly in muon system.

Physics goals of ATLAS detailed in “Detector and Physics Performance” TDR May 1999.

Short term milestones

- Validation of new fast Simulation tool (WBS 2.2.2.1.3)
- Physics Validation of Geant-4. – Review December 2000
  Note that Geant-4 simulation (WBS 2.2.1.3.6.2) will be used for MDC0 (12/01).
- Trigger TDR, Date TBD. Will use simulation sets from Physics TDR
- Physics meeting in Lund Sept 12-15 2001
  Review simulation tools
  Update physics since TDR

Longer term milestones

- Mock data challenges beginning December 2001
- MDCII (10/02-10/03) will provide samples for testing and physics studies
- Physics readiness document – summer 2004.
  Provides documentation and assessment of all physics tools to be used during the analysis phase.

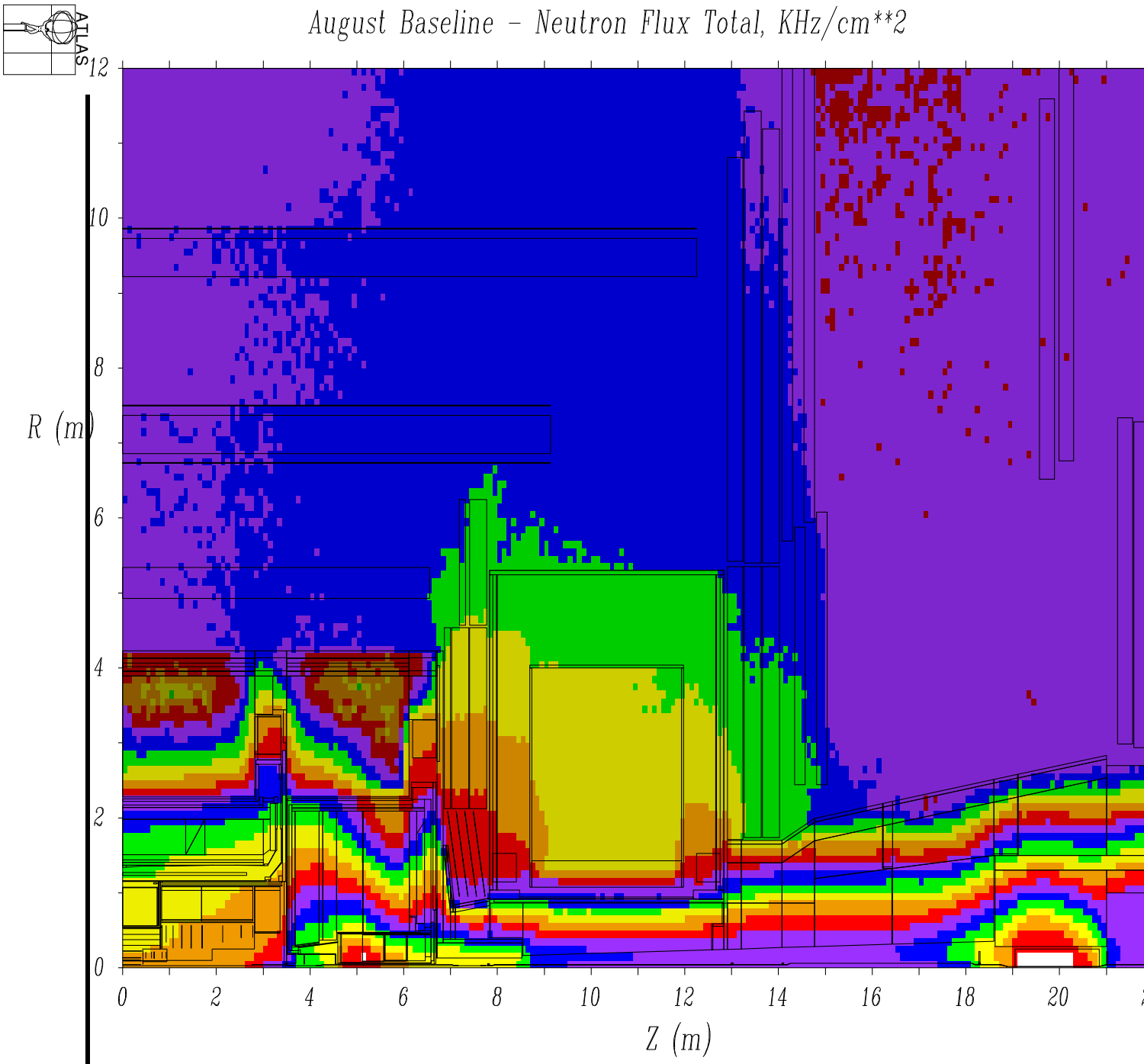
Examples of Current Activity – Background group

Backgrounds in the Muon system are a very important problem

Simulated using GEANT3/GCALOR

Very CPU intensive

Recent results from studies carried out on the BNL Linux system (Shupe)


August Baseline - Neutron Flux Total, KHz/cm**2
R (m)
Z (m)
0
2
4
6
8
10
12
14
16
18
20

Example of Current Activity – LHC Upgrades??

- Request from CERN management for physics range of two possible upgrades
- Luminosity increase to 10^{35} cm^{-2} sec^{-1}?
- Energy of 28 TeV
- Luminosity upgrade is less interesting
  Pile-up limits some physics: tagging of forward jets in Higgs events fails. More demanding on detector upgrades
- Energy upgrade implies $10\times$ rate for interesting physics
  Would allow many more detailed measurements of new physics

Functioning tools needed at all times

Conclusions

- On project activities increasing
- Much work on support and integration of physics tools
- More work needed
- Need more FTE's to fully implement and maintain all tools
- US must carry its share.

Appendix

HepMC

Matt Dobbs and Jorgen Beck Hansen

Intended as a replacement for HEPEVT common

- Note StdHep++ (4.08) interface is similar to FORTRAN – not really adequate

Supports modularization of Generators, physical model

Event is described as a generic tree structure with particles and vertices

8 Classes + 6 Utility classes (IO mainly)

Can store spin density matrices (if needed)

Iterators for navigation

Depends on STL and CLHEP

Has its own Particle data service, not adequate

Integration into Athena: Base Class for Generator Modules

- Base class GenModule implements common functionality:
  - Access HepMC ParticleTable
  - Instantiate CLHEP Random Engine
  - Throw Poisson (if required) for Number of Events
  - Call Generator (see below)
  - Load event into Transient Store
- Provides hooks for child class (virtual methods):
  - genInitialize() [Once at start of job]
  - genFinalize() [Once at end of job]
  - callGenerator() [Every event]
  - fillEvt(GeneratorEvent* evt) [Every event]

Adding Monte Carlo Information to Transient Store

- HepMC defines generator independent description of event
- In order to add to Transient Store, define a class

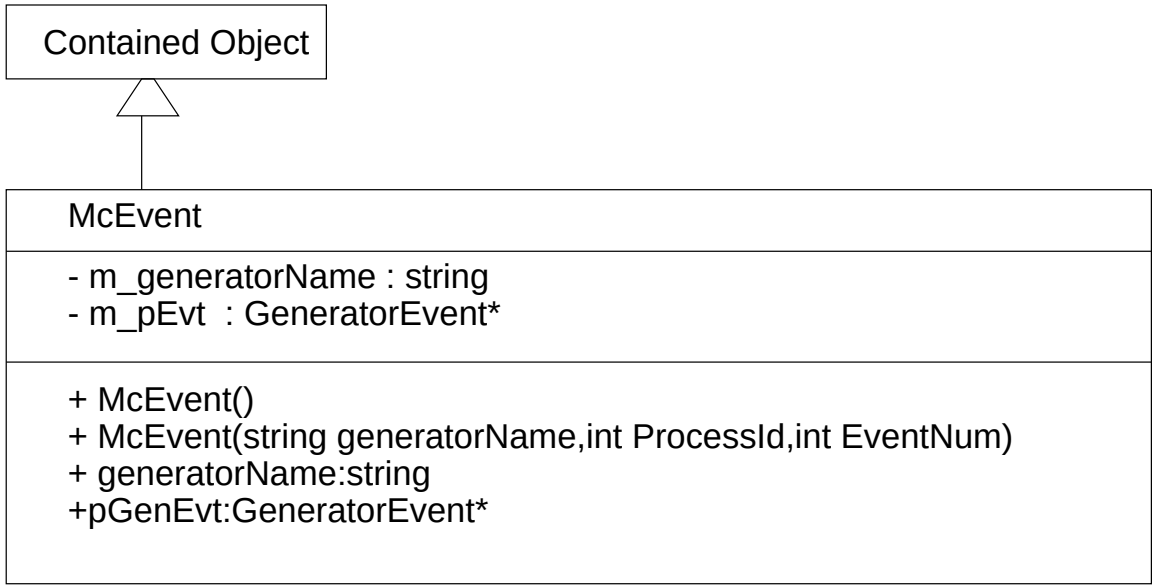
  McEvent:: public ContainedObject

  that contains generator name and HepMC::GeneratorEvent
- Since several McEvents within a given physics event (hard scatter plus N min bias):

  typedef ObjectVector<McEvent> McEventCollection

  Interface is identical to STL vector

McEvent Class Diagram



Generator Specific SubClasses

- Status:
  - EventService for generating event header (Event/EventManagement classes) (Done)
  - Atlas Specific Tunings should reside here so that they are loaded automatically
  - Single Particle Gun (Done)
  - Isajet (Done)
  - Pythia (Done)
    - Provided Interface to pass parameters at run-time
    - Now gets parameters via JobOptions service (Scripting interface will improve this)

```
PythiaModule.PythiaCommand = {"pysubs msel 13","pysubs ckin 3 18.","pypars m
43 2"};
```

Selects $Z + jet$, $P_T > 18$ GeV, no Z/γ interference.

– Generator Level Filter Example – In Progress

– Herwig – In progress

– Used by new fast simulation, part of December 00 Milestone

- Other Generators/decay packages will be added in 2001 – Manpower limited

  Note: Support person added in FY02 to assume responsibilities for development/maintenance of these interfaces (2.1.1.X.2)

  A software agreement will be negotiated to cover this activity